Appendix 5

WORKED EXAMPLE OF CALCULATION OF REFERENCE FLYOVER HEIGHT AND REFERENCE CONDITIONS FOR SOURCE NOISE ADJUSTMENTS FOR CERTIFICATION OF LIGHT PROPELLER DRIVEN AEROPLANES TO ICAO ANNEX 16, VOLUME 1, CHAPTER 10

1. INTRODUCTION

The reference flyover height for an aeroplane certificated to Chapter 10 of Annex 16 is defined for a point 2500 m from start of roll beneath a reference flight path determined according to the take-off reference procedure described in Paragraph 10.5.2 of the Annex. An expression for the reference flyover height in terms of commonly approved performance data and an example of how such an expression may be worked are presented in this Appendix. The relationship between this reference height and the conditions to which source noise corrections are to be made is also explained.

2. TAKE-OFF REFERENCE PROCEDURE

The take-of reference procedure for an aeroplane certificated to Chapter 10 is defined under sea level, ISA conditions, at maximum take-off mass for which noise certification is requested, in Paragraph 10.5.2 of the Annex. The procedure is described in terms of two phases.

The first phase commences at "brakes release" and continues to the point where the aircraft has reached a height of 15 m (50 ft) above the runway (the point of interception of a vertical line passing through this point with a horizontal plane 15 m below is often referred to as "reference zero").

The second phase commences at the end of the first phase and assumes the aeroplane is in normal climb configuration with landing gear up and flap setting normal for "second segment" climb.

Note that in this respect the reference "acoustic" flight path ignores the "first segment" part of the flight path, during which the aircraft accelerates to normal climb speed and, where appropriate, landing gear and flaps are retracted.

3. EXPRESSION FOR REFERENCE HEIGHT

The reference flyover height is defined according to the take-off reference flight path at a point 2500 m from start of roll for an aeroplane taking-off from a paved, level runway under the following conditions:

- sea level atmospheric pressure of 1013.25 hPa;
- ambient air temperature of 15°C, i.e. ISA
- relative humidity of 70 per cent; and
- zero wind.

This height can be defined in terms of the approved take-off and climb performance figures for the conditions described above as follows:

$$H_R = \left(2500 - D_{15}\right)\tan\left(\sin^{-1}\left(RC/V_y\right)\right) + 15 \qquad \text{Equation 1}$$

where: H_R is the reference height in metres;

D_{15} is the sea level, ISA take-off distance in metres to a height of 15 m at the maximum certificated take-off mass and maximum certificated take-off power;

RC is the sea level, ISA best rate of climb (m/s) at the maximum certificated take-off mass and the maximum power and rpm that can be continuously delivered by the engine(s) during this second phase; and

V_y is the best rate of climb speed (m/s) corresponding to *RC*.

The performance data in many flight manuals is often presented in terms of non SI units. Typically the take-off distance (expressed in feet) is given to a height of 50 ft, the rate of climb is expressed in feet per minute and the air speed in knots. In such instances the expression for reference flyover height, H_R ft, becomes:

$$H_R = (8203 - D_{50}) \tan\left(\sin^{-1}\left(RC/101.4V_y\right)\right) + 50 \qquad \text{Equation 2}$$

where: D_{50} is the sea level, ISA take-off distance in feet to a height of 50 ft;

RC is the sea level, ISA best rate of climb (ft/m); and

V_y is the best rate of climb speed (kt).

The performance figures can normally found in the performance section of an aircraft's flight manual or pilot's handbook. Note that for certain categories of aircraft a safety factor may be applied to the take-off and climb performance parameters presented in the flight manual. In the case of multi-engined aircraft it may be assumed that one engine is inoperative during part of Phase 1 and during Phase 2. For the purpose of calculating the "acoustic" reference flight path the take-off distance and rate of climb should be determined for all engines operating using gross, i.e. unfactored, data.

In addition V_y, the best rate of climb speed, used in the expression above is defined as the true air speed (TAS). However in the flight manual speed is normally presented in terms of indicated airspeed (IAS). This should be corrected to the calibrated airspeed (CAS) by applying the relevant position error and instrument corrections for the airspeed indicator. These corrections can also be found in the manual. For an ISA day at sea level the TAS is then equal to the CAS.

4. REFERENCE CONDITIONS FOR SOURCE NOISE ADJUSTMENTS

Paragraphs 5.2c and 5.2d of Appendix 6 of the Annex 16, Volume 1 describe how corrections for differences in source noise between test and reference conditions shall be made.

The reference helical tip Mach number and engine power are defined for the reference conditions above the measurement point, i.e. the reference atmospheric conditions at the reference height, H_R.

The reference temperature at this height is calculated under ISA conditions, i.e. for an ambient sea level temperature of 15°C and assuming a standard temperature lapse rate of 1.98°C per 1000 ft. The reference temperature, T_R °C, can be defined as:

$$T_R = 15 - 1.98\left(H_R/1000\right) \qquad \text{Equation 3}$$

The reference atmospheric pressure, P_R hPa, is similarly calculated at the reference height for a standard sea level pressure of 1013.25 hPa assuming a standard pressure lapse rate:

$$P_R = 1013.25\left[1 - \left(6.7862 \text{x} 10^{-6} H_R\right)\right]^{5.325} \qquad \text{Equation 4}$$

5. WORKED EXAMPLE

A worked example is presented for the calculation of reference flyover height and the associated reference atmospheric conditions.

4.1 Example of reference flyover height calculation

In Figure 5-1 extracts are presented from the performance section of a flight manual for a typical light , single engined propeller driven aeroplane.

The introduction contains a statement to the effect that the information is derived from "measured flight test data" and includes "no additional factors".

The take-off distance to 50 ft at the reference conditions of Chapter 10 can be read from the table of take-off distances presented for a paved runway at the maximum certificated take-off weight of 1920 lb. Thus D_{50} is 1370 ft.

The rate of climb at the reference conditions can similarly be read from the rate of climb table. Thus *RC* is 1000 ft/m.

The climb speed associated with the rate of climb figures is given as 80 kIAS. The corresponding true air speed at the reference conditions of Chapter 10 is equal to the indicated airspeed corrected according to the airspeed calibration table at the appropriate flap setting of 0°. Thus V_y is 81 kTAS.

Entering these parameters into the expression for reference height (ft) given in Equation 2 gives:

$$H_R = (8203 - 1370)\tan\left(\sin^{-1}(1000/101.4 \times 81)\right) + 50$$

and so $H_R = 888$ ft .

4.2 Example of calculation of reference atmospheric conditions

The reference temperature at the reference height, H_R, is given by Equation 3:

$$T_R = 15 - 1.98(888/1000)$$

and so $T_R = 13.2\ ^\circ\text{C}$.

The reference pressure at this height is given by Equation 4:

$$P_R = 1013.25\left[1 - \left(6.7862\text{x}10^{-6}\,\text{x}888\right)\right]^{5.325}$$

and so $P_R = 981$ hPa .

SECTION 5

PERFORMANCE

1. INTRODUCTION

The data processed in this section enables flight planning to be carried out for flights between airfields with various altitudes, temperatures and field lengths. The information is derived from measured flight test data using CAA approved methods and factors to cover all the conditions shown. The data assumes average pilot skill and an aircraft engine and propeller in good condition.

No additional factors are included and it is the pilots responsibility to apply safety factors which must not be less than those.....

6. AIRSPEED CALIBRATION

0° Flap	K**IAS** KCAS	- -	60 61	70 71	**80 81**	90 91	100 101	110 111	120 121	130 131	180 181
15° Flap	KIAS KCAS	50 51	60 61	70 71	80 81	85 86	- -	- -	- -	- -	- -
35° Flap	KIAS KCAS	50 50	60 59	70 69	80 79	85 84	- -	- -	- -	- -	- -

TAKE-OFF DISTANCE - PAVED RUNWAY (1)
CONDITIONS
Flaps - 15°.....Rotation speed - 53 KIAS
Power - Full throttle.....Speed at 50 ft - 65 KIAS
Weight - 1920 lbs

AIRFIELD HEIGHT FT	ISA -20°C		ISA -10°C		**ISA**	
	Grnd Roll	Total to 50 ft	Grnd Roll	Total to 50 ft	Grnd Roll	**Total to 50 ft**
Sea Level	530	1230	565	1290	600	**1370**
5000	1045	2835	1065	2435	1090	2580
10000	1465	3335	1490	3390	1510	3435
AIRFIELD HEIGHT FT	ISA +10°C		ISA +20°C		ISA +30°C	
	Grnd Roll	Total to 50 ft	Grnd Roll	Total to 50 ft	Grnd Roll	Total to 50 ft
Sea Level	700	1580	750	1715	840	1900
5000	1170	2670	1295	2840	1290	2905
10000	1575	3560	1610	3695	1670	3790

RATE OF CLIMB
CONDITIONS
Flaps UP
Full throttle
Weight - 1920 lbs
Speed - 80 KIAS

PRESSURE ALTITUDE FT	RATE OF CLIMB FEET/MINUTE			
	ISA-20°C	ISA	ISA+10°C	ISA+20°C
Sea Level	1035	**1000**	915	825
1000	980	945	860	770
2000	925	890	805	720
3000	870	830	750	665
4000	815	775	695	610
5000	765	720	640	560
6000	700	665	585	505
7000	635	605	560	450
8000	570	550	475	395
9000	495	480	410	335
10000	415	405	335	270

Figure 5-1. Example of Flight Manual Performance Section